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SUBGRADE SOIL CLASSIFICATION SYSTEM USED IN GEORGIA

by L. W. Freeman

SOIL MECHANICS AND FOUNDATIONS DIVISION

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SUBGRADE SOIL CLASSIFICATION SYSTEM USED IN GEORGIA

L. W. Freeman

Subgrade as defined by the Georgia State Highway Department specifications is that portion of the completed roadbed upon which the temporary surface course, subgrade treatment, base course or pavement is to be placed. In other words, it becomes the foundation for the superimposed construction necessary to carry the vehicles along the roadway. However, this type of foundation in its conception of engineering design is considerably different from the ordinary bridge structure or building structure in that the bridge or building structure exerts principally static loads to the foundation with live loads playing a minor part in the ultimate supporting value of the foundation, while roadway subgrade is subjected primarily to live loads with static load playing a relatively unimportant part in the design. However, foundation principals involved in the design of the two types of construction may be considered somewhat similar, but the treatment of the principal loads with relation to stress analysis is different.

The characteristics that are usually considered to control the design of a foundation are strength and compressibility. Therefore, in studying subgrade supporting values these two factors must be taken into consideration, and I will attempt to bring out the role of these two characteristics in the development of the classification system which is now used as a standard by the State Highway Department of Georgia.

It become quite evident several years ago that the classifications which were being used for design purposes were not satisfactory in that where the system was applied on a number of projects, it was found that the foundation soils as rated by the system to need subgrade treatment stood up exceptionally well under the construction equipment and had served satisfactorily as a subgrade under old pavements. At the same time other soils which had been rated under the same system as requiring no treatment were actually requiring treatment to get the construction equipment through. Therefore, with these facts before us, a project was set up to study behavior of soils under the old pavements and develop, if possible, a rating system that might avert in the future some of the failures that were developing.

By driving over hundreds of miles of old pavements and studying the actual behavior of soils, and visually examining and studying large samples taken, it was noted that those soils which had failed appeared to have much less body than the satisfactory subgrade materials. Since field studies showed that subgrade soils usually serve somewhere near maximum density, as determined by A.A.S.H.O. Test Method T-99-49, when originally compacted to this density, tests were conducted on the samples taken during the field trips, and the maximum density at optimum moisture determined in the Laboratory. Knowing that soil pressures allowed for building foundations varied from 10 to 40 tons per square foot on solid rock down to one to two tons on soft wet clay, it was conceived that the density is one means of measuring the supporting value of a foundation material. Therefore, it was concluded to study the subgrade soils from this angle.

Figure 1 shows a straight line with the densities plotted off from solid rock to the very light fluffy rock flour. It will be noted that this chart shows a dividing line at 100 pounds per cubic foot density. Those soils whose densities lie between the 100 and 165 pounds were found to be those which were acting satisfactorily while those below the 100 pounds were acting unsatisfactorily and showed the necessity for strengthing either by inc_easing the pavement depth or by subgrade treatment.

As the field studies were extended, it was found in some sections of the State that the density fell within the limits for satisfactory subgrade materials in other sections, but the soil had failed under service. It was concluded that in these instances the density of the soil must at some stage during service become less than the maximum density at optimum moisture. Knowing that three of the components of the soil; namely, gravel, sand and silt hold closely to their original volume through any change of temperature or moisture, studies were conducted upon the clay fraction. Our studies discloses that certain clays swell a considerable amount upon becoming wet, the swelling breaking the complete soil structure and increasing the void content resulting in a density lower than previously found satisfactory.

Therefore, it was further concluded that it would be necessary to set a limitation on the volume change as well as upon the density so that the change of volume upon becoming wet under normal field conditions would not change the volume to the extent of expanding the soil mixture such that the density would be lowered below that required to support the loads.

Field observations of those soils which showed distress together with the Laboratory volume change determinations set the limitations as shown in Figure 2.

While the values shown in Figure 2 are considered generally satisfactory for subgrade soils it has been found necessary to limit the total volume change for certain types of construction to conform to the Standard Specifications of the Department.

For sand bituminous road mix and limerock base construction the specifications require the subgrade to be sandy soils which are considered friable and stable and which may contain a small percentage of clay. Therefore, by tests and visual examinations a maximum volume change of 10% and a total clay content of 20% was allowed.

Our specifications allow under certain conditions subgrade soils which have relatively high clay contents if these soils are stable when well drained. By the system of classification now being used these soils are designated as those with a total volume change of between 15 and 20%, and are generally considered satisfactory as subgrade under bituminous concrete or Portland cement concrete provided the soils have sufficient sand to prevent pumping.

Therefore, the limits as required by these circumstances bring about a change in the chart as shown in Figure 2, and we now have a subgrade classification chart as shown in Figure 3.

We wish to point out that density reflects both the gradation and particle shape of the material. Hogentogler brought out that density varies with gradation and showed that a compacted soil mixture, all passing the No. 10 sieve and containing 8% clay, 15% silt and 77% sand has a weight per cubic foot of 130 pounds and after removal of sand to a gradation of 68% clay, 20% silt and 12% sand the soil has a weight per cubic foot of 113 pounds. Sowers and Sowers in their book "Introductory Soil Mechanics and Foundations" bring out that angular soil grains tend to form much looser structures or less dense

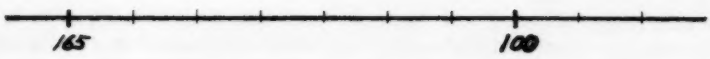
structure than rounded grains because their sharp edges and points hold the grains further apart and that mica flakes tend to produce an even lower density since the flakes bridge over the voids in the bulky grains.

Density is a measure of the bearing-capacity or strength as can be seen, by comparing the soil pressured allowed by the Portland, Oregon Bldg. code quoted in Kidden-Parker, Architects and Builders Hand Book, 1931, wherein rock is allowed 16 tons, gravel or coarse sand well cemented 8 tons and very fine sand 4 tons. Each of these materials will have a different density although they may be composed of basically the same petrographic materials.

Density is also a measure of compressibility, which reflects the settlement. It has been brought out in a number of text books that settlement decreases as the density increases both as to the state of well compacted against loose, or so called relative density; as well as dense with a low void content against low density with a high void content.

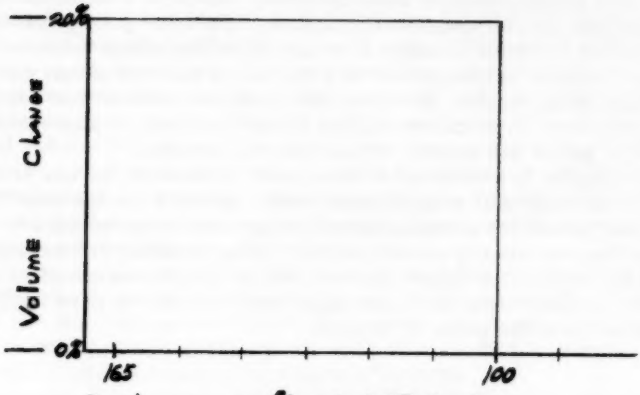
Therefore, in conclusion a classification based on the use of dense soils and those which will remain dense under moisture fluctuations to which a roadway foundation is subjected takes into consideration the two characteristics that are usually considered to control the design of a foundation.

It is realized the limitations now set up are not the complete and final answer to subgrades, but it has apparently resulted in practically eliminating failures from this cause in Georgia.



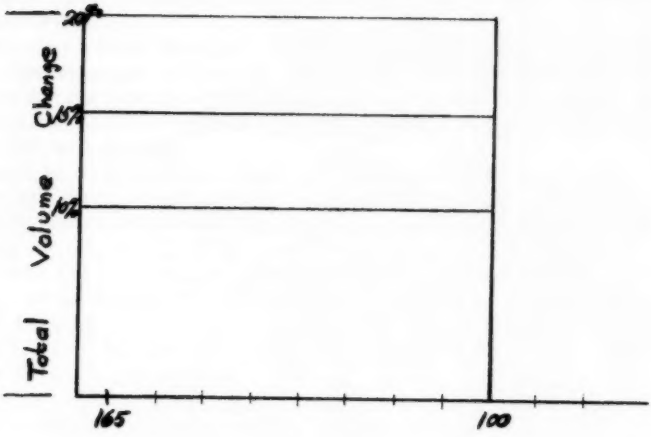
Pounds per cu ft. at 2.65 Sp. Gr.

FIG. 1



Pounds per cu ft. at 2.65 Sp. Gr.

FIG. 2



Pounds per cu ft at 2.65 Sp. Gr.

FIG. 3

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